CLAIMS

1. A semiconductor device comprising:

a semiconductor substrate in which a trench is formed;

a source region and a drain region, each of which is buried in the trench and contains an impurity of the same conductive type;

a semiconductor FIN buried in the trench and provided between the source region and the drain region;

a gate insulating film provided on a side surface of the semiconductor FIN as well as an upper surface of the semiconductor FIN; and

a gate electrode provided on the gate insulating film.

2. The semiconductor device of claim 1, wherein the semiconductor FIN is made of one material selected from the group consisting of Si, $Si_{1-x}Ge_x$ ($0 < x \leq 1$), and $Si_{1-y-z}Ge_yC_z$ ($0 < y < 1$, $0 < z < 1$, $0 < y + z < 1$).

3. The semiconductor device of claim 1, wherein the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate,

wherein an isolation insulating film is further provided between part of the semiconductor substrate located in a side wall portion of the trench and part of the gate electrode located over the side wall of the semiconductor FIN; and

wherein an insulating film is further provided between part of the semiconductor substrate in which the trench is not formed and the gate electrode.

4. The semiconductor device of claim 1, wherein the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate,

wherein the gate insulating film is provided on the side and upper surfaces of the semiconductor FIN as well as part of the semiconductor substrate in which the trench is not formed, and

wherein part of the gate insulating film located on the part of the semiconductor substrate in which the trench is not formed is interposed between the semiconductor substrate and the gate electrode.

5. The semiconductor device of any one of claims 1 through 4, wherein the semiconductor FIN is formed so as to have a convex shape when viewed from the bottom of the trench.

6. A semiconductor device comprising:

a first field-effect transistor including a semiconductor substrate in which a trench is formed, a first source region and a first drain region each of which is buried in the trench and contains an impurity of the same conductive type, a semiconductor FIN buried in the trench and provided between the first source region and the first drain region, a first gate insulating film provided on a side surface of the semiconductor FIN as well as an upper surface of the semiconductor FIN, and a first gate electrode formed on the first gate insulating film; and

a second field-effect transistor including a second gate insulating film provided on the semiconductor substrate, a second gate electrode provided on the second gate insulating film, and second source and drain regions each of which contains an impurity and is provided in a region of the semiconductor substrate located on a side of and under the second gate electrode.

7. The semiconductor device of claim 6, wherein the first gate electrode is provided on the first gate insulating film so as to extend over the semiconductor substrate, and

wherein the first field-effect transistor further includes an isolation insulating film formed between part of the semiconductor substrate located in a side wall portion of the trench and part of the first gate electrode provided over the side surface of the semiconductor FIN and a second insulating film formed between the semiconductor substrate and the first gate electrode.

8. The semiconductor device of claim 6, wherein the first gate electrode is provided on the first gate insulating film so as to extend over the semiconductor substrate,

wherein the first gate insulating film is provided on the side and upper surfaces of the semiconductor FIN as well as part of the semiconductor substrate in which the trench is not formed, and

wherein part of the gate insulating film located on the part of the semiconductor substrate in which the trench is not formed is interposed between the semiconductor substrate and the first gate electrode.

9. A method for fabricating a semiconductor device, the device including a semiconductor substrate in which a trench is formed, a source region and a drain region each of which is buried in the trench and contains an impurity of the same conductive type, a semiconductor FIN buried in the trench and provided between the source and drain regions, a gate insulating film provided on a side surface of the semiconductor FIN as well as an upper surface of the semiconductor FIN, and a gate electrode formed on the gate insulating film, the method comprising steps of:

(a) forming a semiconductor layer in the trench formed in the semiconductor substrate;

(b) forming a gate insulating film on an upper surface of part of the semiconductor layer which is to be the semiconductor FIN as well as a side surface of the part of the semiconductor layer;

(c) forming a gate electrode on the gate insulating film; and

(d) introducing an impurity into the semiconductor layer, using the gate electrode as a mask, to form a source region and a drain region in regions of the semiconductor layer located on sides of and under the gate electrode, respectively, and then forming a semiconductor FIN in a region of the semiconductor layer interposed between the source region and the drain region and located directly under the gate electrode.

10. The method for fabricating a semiconductor device of claim 9, wherein in the process step (c), the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate, and

wherein the method further includes the step (e) of forming an isolation insulating film in a side wall portion of the trench and the step (f) of forming an insulating film on the semiconductor substrate.

11. The method for fabricating a semiconductor device of claim 9, wherein the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate,

wherein the gate insulating film formed in the step (b) is provided on side and upper surfaces of part of the semiconductor layer which is to be the semiconductor FIN as well as part of the semiconductor substrate in which the trench is not formed, and

wherein in the step (c), the gate electrode is provided so that the gate insulating film is interposed between the part of the gate electrode and the semiconductor substrate.

AMENDED CLAIMS

[received by the International Bureau on 06th August, 2004 (06.08.04)
original claims 1, 6, 9, 10 and 11 amended; other claims remaining unchanged (5 pages)]

1. (Amended) A semiconductor device comprising:

a semiconductor substrate in which a trench is formed;

a source region and a drain region, each of which is buried in the trench and contains an impurity of the same conductive type;

a semiconductor FIN buried in the trench and provided between the source region and the drain region;

a gate insulating film provided on a side surface of the semiconductor FIN as well as an upper surface of the semiconductor FIN; and

a gate electrode having two end portions each of which protrudes downward in the trench so as to extend along the gate insulating film on the semiconductor FIN and formed on the gate insulating film.

2. The semiconductor device of claim 1, wherein the semiconductor FIN is made of one material selected from the group consisting of Si, $Si_{1-x}Ge_x$ $(0 < x \leq 1)$, and $Si_{1-y-z}Ge_yC_z$ $(0 < y < 1, 0 < z < 1, 0 < y + z < 1)$.

3. The semiconductor device of claim 1, wherein the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate,

wherein an isolation insulating film is further provided between part of the semiconductor substrate located in a side wall portion of the trench and part of the gate electrode located over the side wall of the semiconductor FIN; and

wherein an insulating film is further provided between part of the semiconductor substrate in which the trench is not formed and the gate electrode.

4. The semiconductor device of claim 1, wherein the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate,

wherein the gate insulating film is provided on the side and upper surfaces of the semiconductor FIN as well as part of the semiconductor substrate in which the trench is not formed, and

wherein part of the gate insulating film located on the part of the semiconductor substrate in which the trench is not formed is interposed between the semiconductor substrate and the gate electrode.

5. The semiconductor device of any one of claims 1 through 4, wherein the semiconductor FIN is formed so as to have a convex shape when viewed from the bottom of the trench.

6. (Amended) A semiconductor device comprising:

a first field-effect transistor including a semiconductor substrate in which a trench is formed, a first source region and a first drain region each of which is buried in the trench and contains an impurity of the same conductive type, a semiconductor FIN buried in the trench and provided between the first source region and the first drain region, a first gate insulating film provided on a side surface of the semiconductor FIN as well as an upper surface of the semiconductor FIN, and a first gate electrode having two end portions each of which protrudes downward in the trench so as to extend along the gate insulating film on the semiconductor FIN and formed on the gate insulating film; and

a second field-effect transistor including a second gate insulating film provided on the semiconductor substrate, a second gate electrode provided on the second gate insulating film, and second source and drain regions each of which contains an impurity

and is provided in a region of the semiconductor substrate located on a side of and under the second gate electrode.

7. The semiconductor device of claim 6, wherein the first gate electrode is provided on the first gate insulating film so as to extend over the semiconductor substrate, and

wherein the first field-effect transistor further includes an isolation insulating film formed between part of the semiconductor substrate located in a side wall portion of the trench and part of the first gate electrode provided over the side surface of the semiconductor FIN and a second insulating film formed between the semiconductor substrate and the first gate electrode.

8. The semiconductor device of claim 6, wherein the first gate electrode is provided on the first gate insulating film so as to extend over the semiconductor substrate,

wherein the first gate insulating film is provided on the side and upper surfaces of the semiconductor FIN as well as part of the semiconductor substrate in which the trench is not formed, and

wherein part of the gate insulating film located on the part of the semiconductor substrate in which the trench is not formed is interposed between the semiconductor substrate and the first gate electrode.

9. (Amended) A method for fabricating a semiconductor device, the device including a semiconductor substrate in which a trench is formed, a source region and a drain region each of which is buried in the trench and contains an impurity of the same conductive type, a semiconductor FIN buried in the trench and provided between the

source and drain regions, a gate insulating film provided on a side surface of the semiconductor FIN as well as an upper surface of the semiconductor FIN, and a gate electrode formed on the gate insulating film, the method comprising steps of:

(a) forming the trench in the semiconductor substrate;

(b) forming an insulating film on a side wall of the trench;

(c) forming a semiconductor layer including the semiconductor FIN in the trench using the insulating film as a mask;

(d) removing the insulating film;

(e) forming a gate insulating film on an upper surface of part of the semiconductor layer which is to be the semiconductor FIN as well as a side surface of the part of the semiconductor layer;

(f) forming a gate electrode on the gate insulating film; and

(g) introducing an impurity into the semiconductor layer, using the gate electrode as a mask, to form a source region and a drain region in regions of the semiconductor layer located on sides of and under the gate electrode, respectively, and then forming a semiconductor FIN in a region of the semiconductor layer interposed between the source region and the drain region and located directly under the gate electrode.

10. (Amended) The method for fabricating a semiconductor device of claim 9, wherein in the process step (f), the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate, and

wherein the method further includes the step (h) of forming an isolation insulating film in a side wall portion of the trench and the step (i) of forming an insulating film on the semiconductor substrate.

11. (Amended) The method for fabricating a semiconductor device of claim 9, wherein the gate electrode is provided on the gate insulating film so as to extend over the semiconductor substrate,

wherein the gate insulating film formed in the step (e) is provided on side and upper surfaces of part of the semiconductor layer which is to be the semiconductor FIN as well as part of the semiconductor substrate in which the trench is not formed, and

wherein in the step (f), the gate electrode is provided so that the gate insulating film is interposed between the part of the gate electrode and the semiconductor substrate.